
Paleontological Resource Inventory and Monitoring

Northeast Coastal and Barrier Network

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On the Cover:

Martin Lister's 1687 figure (shown) and description of the mollusk *Chesapecten jeffersonius* is the first such publication of fossil material from North America. *Chesapecten jeffersonius* is just one of hundreds of mollusk species found within Colonial National Historical Park. See page 9 for more information. Image from Ward and Blackwelder, 1975.

INTRODUCTION

Paleontological resources, fossils, are any remains of life preserved in a geologic context. These fossils are non-renewable resources that possess great scientific and educational values.

Establishment of baseline paleontological resource data is essential for the appropriate management of fossils found within National Park Service (NPS) areas. Although more than 160 NPS areas have been identified with paleontological resources, only a small percentage of these parks have adequate baseline paleontological resource data.

In conjunction with the NPS Geologic Resources Division and NPS Inventory and Monitoring Networks, paleontological resource inventories have been initiated in dozens of parks servicerwide. This report represents paleontological resource inventory and monitoring data compiled for the parks within the Northeast Coastal and Barrier Network (CBN).

The CBN was formed to address coastal ecosystem resource issues throughout the northeast. The network contains eight NPS areas in five states, Assateague Island National Seashore (Maryland and Virginia), Cape Cod National Seashore (Massachusetts), Colonial National Historical Park (Virginia), Fire Island National Seashore (New York), Gateway National Recreation Area (New York and New Jersey), George Washington Birthplace National Monument (Virginia), Sagamore Hill National Historic Site (New York), and Thomas Stone National Historic Site (Maryland) as shown in Figure 1. These parks together cover 141,000 acres and host about 18 million visitors each year. The parks were set aside for a variety of historical reasons from preserving sites of the earliest American settlements at Colonial NHS through the urban recreational setting of Gateway NRA. While some parks such as Cape Cod NS and Assateague Island NS were set aside in part to preserve natural features, none of the parks' enabling legislation mention paleontological resources.

The CBN contains a variety of geologic features including barrier islands, beach deposits, and glacial deposits. Barrier islands, such as Assateague Island NS and Fire Island NS, and beaches, such as those found at Gateway NRA and George Washington Birthplace NM, are very transient geological features. These coastal features are created and destroyed through relentless wave action and erosion. These islands and beaches also are usually very young, geologically speaking, with ages ranging from recent to tens of thousands of years old. The erosive character of such features, coupled with their young age, often precludes their inclusion in discussions of paleontological resources. Glacial deposits, such as those found at Sagamore Hill NHS or Cape Cod NS, are also not frequently associated with paleontological material.



Figure 1. Map of CBN park areas.

Even though none of the parks were set aside specifically for paleontological resources, and many are made up of transient and erosional geological features, six CBN parks are known to contain, or may contain, paleontological resources. These fossils range from microfossils such as foraminifera and pollen

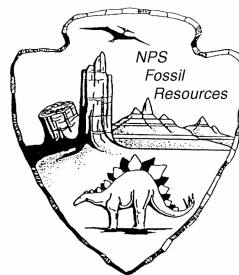
to a large number and variety of mollusks and sharks teeth. Large marine mammal fossils have also been found. Taken together, fossils from the CBN contribute much to a greater

understanding of past life on earth. One fossil in particular is of historical significance. The mollusk *Chesapecten jeffersonius*, found near Yorktown in Colonial NHS, represents the first fossil ever figured and described from North

America in 1687. The original fossil itself may have been collected from within the current boundaries of Colonial NHS.

Continued paleontological resource inventories will continue to expand our knowledge of the history of life represented throughout the National Park Service. Although more than 160 parks have already been identified as containing paleontological resources, much of what we know about life on earth remains to be discovered.

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COLONIAL NATIONAL HISTORICAL PARK

Colonial National Historical Park (COLO) was proclaimed July 3, 1930 and established December 30, 1930. The park preserves a number of features and places prominent in early American history. Jamestown Island was the site of the first permanent English settlement in North America. The culminating battle of the American Revolution, and subsequent surrender of British forces, occurred at Yorktown in 1781. Cape Henry Memorial marks the approximate site of the first landing of Jamestown colonists in 1607. The Colonial Parkway winds 37 kilometers (23 miles) between Yorktown and Jamestown Island, connecting the two units of the park. The road also passes through the colonial town of Williamsburg. Yorktown National Cemetery is the site of thousands of Civil War interments.

BASELINE PALEONTOLOGICAL RESOURCE INVENTORIES

There have been no formal paleontological inventories undertaken at Colonial National Historical Park. Paleontological or geological scoping sessions have likewise not been completed for the park and there are no collections of paleontological material in the park's museum. While formal inventories and collections have not been conducted by the park, there are extensive paleontological resources known from COLO. In fact, the first figured and described fossil from North America may have been collected from Yorktown Formation sediments in what is now COLO.

Johnson (1972) maps the Upper Pleistocene Norfolk Formation throughout the Beaverdam Creek area south of Yorktown and in very small area southeast of Moore House near the park boundary. This name is no longer used, however, and Mixon and others (1989) map the area as the "middle" Pleistocene Shirley Formation and the "middle" (?) Pleistocene Chuckatuck Formation.

The Shirley Formation is made up of sand, gravel, silt, and clay, representing surficial deposits of river terraces (Mixon, et al., 1989). Organic material is common in the Shirley Formation including *in situ* tree stumps and leaves and seeds of cypress, oak, and hickory trees. Additional fossils are reported in the Shirley Formation in the lower James River and Rappahanock River area, including *Crassostrea virginica*, *Mulinia*, *Noetia*, and *Mercenaria*, among other mollusks. An *Astrangia* (coral) fossil was dated from the Shirley Formation and yielded an approximate age of 184,000 years before present (Mixon, et al., 1989).

The Chuckatuck Formation is made up of sand, silt, and clay, with minor amounts of peat, representing surficial deposits of mid-level coast-parallel plains and equivalent river terraces (Mixon, et al., 1989). The Chuckatuck is not particularly fossiliferous, although *Ophiomorpha* burrows have been reported (Mixon, et al., 1989).

The late Pliocene or early Pleistocene Windsor Formation is well exposed throughout the Yorktown area of COLO, especially at the Zook marl pit located just northeast of the intersection of Virginia Routes 238 and 639. The Windsor Formation contains a lower cross-bedded sand and bedded silt member and an upper silty-clay, sandy-silt, and clayey sand member (Johnson, 1972). The only fossils *in situ* within the Windsor Formation are vertical knobby burrows similar to those formed by *Calianassa major* (modern ghost shrimp) (Johnson, 1972). Mollusk molds formed in the minerals goethite, hematite, and limonite are found in the lower beds of the Windsor Formation. These molds are most likely from Yorktown Formation mollusks, reworked into the younger beds of the Windsor Formation (Johnson, 1972).

The lower and upper Pliocene Yorktown Formation (approximately 4.5-3 million years old) is exposed throughout the coastal plain of Virginia and North Carolina. Within COLO, the Yorktown Formation was exposed mainly along the banks of the York River. Additional exposures were found near the mouths of creeks feeding into the York and along the banks of Yorktown Creek and Ballard Creek in particular. The impact of erosion control measures on the exposures of the Yorktown Formation is mentioned at the end of the COLO summary. Overall, the Yorktown Formation is a marine unit composed of silts, sands, and crossbedded coquinas (shell hash). The formation is abundantly fossiliferous. The vast majority of the fossil material described from the Yorktown Formation is molluscan, and many of the taxa were named based on material from the immediate Yorktown area.

The Yorktown Formation has been the subject of a voluminous amount of geological and paleontological research. Much of the early work describing the Yorktown Formation took place within current park boundaries or within close proximity to them. However, exact locality information is sometimes not clear. Some of this early work is very significant historically.

Ward and Blackwelder (1975) speak to the extraordinary significance of a fossil from the Yorktown area in that it represents the first description and figure of a fossil from North America, published by Martin Lister in 1687! The story behind this unique fossil is summarized below.

Martin Lister described and figured an unnamed scallop-like shell in his “*Historiae Conchyliorum, Liber III*” (History of the Mollusks, Third Book). This fossil has had an interesting history since this first description more than 315 years ago. Initially, Lister misinterpreted the locality where the shell was collected. The fossil was labeled “a virg.” which Lister interpreted as “from the Virgin Islands”, hence his addition of “Ind Occ”, meaning Indies Occidentale, or West Indies, to the label (Ward and Blackwelder, 1975). However, fossils of this type are not known from the Virgin Islands (L. Ward, personal communication, 2003). Paleontologist Thomas Say, in 1824, recognized the shell as probably coming from the Atlantic Coastal Plain of the United States, instead of the Virgin Islands, and named it *Pecten jeffersonius* (now assigned to *Chesapecten jeffersonius*; Ward and Blackwelder, 1975). However, Say was also confused as to the exact locality of additional *Chesapecten jeffersonius* material. He incorrectly described the material as coming from Miocene deposits on the Saint Mary’s River in Maryland. Given the abundance of *Chesapecten jeffersonius* throughout southeastern Virginia, the “a virg.” most likely meant “from Virginia” (Ward and Blackwelder, 1975). Recognizing the historical significance and the abundance of the fossil, the Virginia General Assembly named *Chesapecten jeffersonius* the state fossil of Virginia in 1993. A copy of Lister’s figure for *Chesapecten jeffersonius* is presented as Plate 1 in Ward and Blackwelder (1975) and is figured on the cover of this report.

While the exact collecting locality of the original specimen is not known, it is from the Yorktown Formation, based on numerous additional finds of *Chesapecten jeffersonius*. The specimen figured by Lister may be from the Kings Creek area, currently located within the U.S. Naval Weapons Station adjacent to Yorktown (G. Johnson, personal communication, 2003). The Colonial Parkway crosses Kings Creek where it joins the York River, within exposures of the Yorktown Formation. If the collection was made near the mouth of Kings Creek, the locality may fall within current boundaries of COLO. Alternatively, the specimen may have been collected in the Indian Field Creek area, the mouth of which is also within current COLO boundaries (L. Ward, personal communication, 2003).

Ward (1993) and Campbell (1993) describe much of the other early work on the Yorktown Formation. References for many of these publications are listed under the “additional references” section at the end of this report.

Lister’s significant description of *Chesapecten jeffersonius* in 1687 was the first description of paleontological material from the area. Lister did not actually visit the area, although many of his specimens were collected from a number of different naturalists working in the Yorktown vicinity (L. Ward, personal communication, 2003). The first description of the Yorktown area by a geologist was in 1824, when Scottish geologist John Finch visited the region and made collections of approximately 50 fossil mollusks (L. Ward, personal communication, 2003). Finch distributed these fossils to a number of prominent scientists at the Academy of Natural Sciences in Philadelphia including Timothy Abbott Conrad, Samuel G. Morton, Isaac Lea, Thomas Say, and J. Green. Say received the majority of the specimens, about 30 fossils (L. Ward, personal communication, 2003). Say described most of these fossils, including *Chesapecten jeffersonius*, in 1824. However, Say and the other scientists (Conrad in 1832 and Lea in 1833) all mistakenly listed the collecting locality for Finch’s fossils as coming from Saint Mary’s River, Maryland (Ward, 1993; Campbell, 1993). Finch and the authors never corrected this error. Therefore many of the original specimens collected from the area (now many of which are housed in the British Museum, London) are listed as coming from Maryland (L. Ward, personal communication, 2003). Conrad returned to the area around Yorktown repeatedly from the 1830s through the 1860s, describing and naming a large number of mollusk fossils (Ward, 1993; Campbell, 1993).

A number of authors during the mid- to late-1800s and early 1900s attempted to catalog and classify Yorktown Formation mollusks from throughout the Coastal Plain of Virginia.

The authors included, among many others, H.C. Lea in 1846 and 1849, d’Orbigny in 1850-1852, Conrad in 1862, Meek in 1864, Meyer in 1888, Shaler in 1890, Dall in 1890-1903, Olsson in 1914 and 1916, and Gardner in 1948 (Campbell, 1993). However, a large number of these publications, especially the earlier ones, contain various taxonomic and/or stratigraphic errors and omissions (summarized in greater detail by Campbell, 1993). These errors are in addition to the erroneous locality information introduced by Lister and Finch. Campbell (1993) goes on to warn all those who “deal casually with the Yorktown faunas” of these discrepancies present throughout a widely scattered literature base.

In 1890, Gilbert Dennison Harris made the first intensive geologic description of the Yorktown Formation, in the area of Yorktown Proper. His elegantly handwritten manuscript was originally unpublished, but has been reproduced by Ward (1993). This “new edition” includes copies of the original pages and drawings along with updated information. Dall and Harris in 1892 also reproduced a portion of Harris’ 1890 manuscript. Harris, in addition to his geologic observations, described in detail the fossil fauna he discovered and collected from the cliffs along the banks of the York River. Harris collected fossils from eight localities along the York River. Seven are most likely within current COLO boundaries and range from Temple Place (Moore House), throughout the bluffs at Yorktown and a few miles upstream from the town, and up to Bellefield (Bellfield). These locations produced a diverse assemblage of gastropods and bivalves. Harris named many of the layers (beds) he studied after the predominant, or most characteristic, fossil species from each respective bed including: *Turritella* (gastropod), *Crepidula* (gastropod), *Striarca centenaria* (bivalve), *Tellina* (bivalve), and *Yoldia limatula* (bivalve). Harris also describes areas of “shell marl” and “fragmentary series” (probably coquina) where the shell material is extraordinarily abundant, but very fragmented. Ward (1993) a complete listing of fossils collected by Harris, all are now curated in the Smithsonian Institution’s National Museum of Natural History. Overall, Harris collected 72 species of gastropods and 69 species of bivalves. Harris also collected a few specimens of brachiopods and *Balanus* (barnacles).

Harris also described and produced a detailed sketch, reproduced in Ward (1993), of the Yorktown Formation (then known as the “Miocene Beds”) exposed from Wormley Creek to Kings Creek. This is significant in that it is one of the only existing sketches and descriptions of the river shoreline from before erosion control features (riprap) were installed in the mid 1950s.

Clark and Miller (of the Maryland and Virginia Geological Surveys) formally applied the name Yorktown Formation to the “Miocene Beds” as the Yorktown Formation rocks were known in 1906.

In 1836, William Barton Rogers, first state geologist of Virginia, briefly described the Yorktown bluffs from Wormley Creek (about one mile southwest of Moore House) to several miles above Yorktown proper. Nearly all of this shoreline is currently administered by COLO (Ward, 1993).

W.C. Mansfield, in 1944, suggested dividing the entire Yorktown Formation into two zones based on mollusk assemblages. The lower Zone 1 contains 105 molluscan species while the upper Zone 2 contains an astounding 507 molluscan species (Campbell, 1993).

Johnson (1972) mapped the geology of the Yorktown area and presented a faunal list from the Yorktown Formation collected from the area. Two localities including the bluffs near Moore House and the Zook marl pit are within COLO boundaries. Johnson also identified two species of Scaphopoda (tusk-shelled mollusks), 39 species of gastropods, 46 species of Pelecypods (bivalves), two species of annelid worms, barnacle and decapod fragments, echinoid spines and plates

Ward and Blackwelder (1980) revised much of the stratigraphy of Chesapeake Group formations of which the Yorktown Formation is the youngest. They renamed strata equivalent to Mansfield’s Zone 1, the Sunken Meadow Member of the Yorktown Formation. They divided Mansfield’s Zone 2 into three members, from oldest (bottom) to youngest (top) they are the Rushmere Member, the Morgarts Beach Member, and the Moore House Member.

The Sunken Meadow Member is a coarse-grained, poorly-sorted, very shelly sand with 27 different species of mollusks (Ward and Blackwelder, 1980). The Rushmere Member is a fine-grained, well-sorted shelly sand, containing a molluscan assemblage very similar to the Moore House Member, described below. The Morgarts Beach Member is a very fine grained sandy to silty clay with some silty sand beds. The quieter-water environment represented in this member contains a molluscan assemblage similar to the Moore House Member, but the fossils are generally less abundant (Ward and Blackwelder, 1980). The Moore House Member is named for exposures still visible along the shoreline of the York River near Moore House within COLO boundaries. The Moore House consists of sandy shell beds and a prominently cross-bedded shell hash (coquina) locally well cemented to form a relatively hard rock. Cornwallis Cave was excavated into the Moore House Member and dramatically displays the crossbedded nature of the coquina (Ward and Blackwelder, 1980; Santucci, et al., 2001). The molluscan assemblage of the Moore House Member contains 71 different species.

Ward and Blackwelder assigned type sections to the Yorktown Formation. Even though Clark and Miller originally named the formation for exposures along the York River (most likely within COLO boundaries), they did not define a

type section. Now that most of the exposures originally studied and named are inaccessible due to riprap, the type section of the Yorktown Formation is found near Rushmere, Virginia along the James River (Ward and Blackwelder, 1980).

McLean (1957) summarized the field collections made by Denise Mongin (Laboratoire de Geologie, Institut Catholique, Paris, France) in 1955 from the bluffs at Moore House within COLO. Mongin collected 66 species from a wide variety of fossils including foraminifera, ostracodes, and mollusks. These fossils are curated in the Institut Catholique museum.

Palmer (1958) reported on an interesting specimen of *Turritella pilsbryi* (gastropod; assigned to *Turritella bipertita* by Campbell, 1993) found with more than 100 young embryos inside the adult shell. The finding of this viviparous (gives birth to live young) specimen is significant in that determining the sex and/or life habit of a fossil is usually impossible. This specimen was found about 14 kilometers (nine miles) north of Yorktown along the York River, and may be within Colonial Parkway right of way. Other similar viviparous specimens have been found in Miocene-age rocks at Plum Point, Maryland (Palmer, 1958).

Campbell (1993) attempted to comprehensively describe the history and taxonomy of all Pliocene-aged mollusks from both the Yorktown and Chowan River formations in Virginia. In this monograph he described a total of 572 molluscan species and subspecies from those formations, the vast majority from the Yorktown Formation. Campbell (1993) also addressed new ideas about the depositional environments of the Yorktown Formation and suggests revisions to the four members named by Ward and Blackwelder (1980). Campbell mentioned the importance of localities not along the riprapped shoreline of the York River, such as the Zook pit (located with COLO boundaries), to future studies of the Yorktown Formation. Campbell also speaks to the significance of the Virginia Yorktown fauna as a whole. The Virginia Yorktown molluscan fauna is of importance to many other Neogene (Miocene and Pliocene) fossil assemblages from the western Atlantic from Massachusetts to the Caribbean, hence it is cited in many of the significant works. The Yorktown fauna is thus a very important part of the more than 1,550 molluscan species identified from the Pliocene of Massachusetts to Florida (Campbell, 1993). Because of the continuous stratigraphy and well-exposed outcrops (before the installation of riprap), the Yorktown Formation faunal assemblage provided stratigraphic context for Yorktown-aged fossils found in other formations throughout the Atlantic Coastal Plain.

Collections of Yorktown Formation fauna are housed in a number of museums around the world. For example, many of Say's described fossils are housed at the British Museum in London. Mongin's specimens are at the Institut Catholique in Paris, while many other early specimens are found in other European museums and collections. Harris' significant collection from the 1890s was made while he was working for the U.S. Geological Survey, hence his collections are at the Smithsonian's National Museum of Natural History in Washington, DC (NMNH; although specimen numbers are prefixed USNM). All together the NMNH houses a huge number (more than 500) of Yorktown Formation mollusk species (Campbell, 1993). Johnson's specimens are curated at the College of William and Mary in Williamsburg. Campbell (1993) also lists collections housed at the American Museum of Natural History (New York), the Academy of Natural Sciences (Philadelphia), the Museum of Comparative Zoology (Harvard), the Wagner Free Institute (Philadelphia), and the Paleontological Research Institute (Ithaca). Specimens described in Ward's 1975 and 1980 publications are curated at the NMNH and the Virginia Museum of Natural History.

Apart from the immense diversity of mollusk fossils, there are a number of other paleontological resources from the Yorktown Formation, both in and around COLO boundaries.

Extensive work on the microfauna, including foraminifera (small single-celled organisms with chambered exoskeletons called 'tests') and ostracodes (bivalved, generally microscopic aquatic crustaceans) of the Yorktown Formation has been conducted and reported in a number of papers.

McLean (1956) described 108 species of foraminifera from the York-James Peninsula. Much of the material is well preserved, although not necessarily abundant. Two of McLean's localities, Yorktown Bluffs and Moore House Beach, are within COLO boundaries. A third locality near the mouth of Felgates Creek (McLean refers to "Felgaters" Creek) may be within COLO boundaries of the Colonial Parkway, or just outside COLO administered land. The Yorktown Bluffs locality produced seven different species or forms of foraminifera including one previously undescribed species. The Moore House Beach locality contained a much more diverse assemblage with 50 species or forms represented, including 11 previously undescribed species. The Moore House Beach foraminifera were collected from excavations along the base of the embankment, and then four feet and six feet above the base. The Felgates Creek assemblage of foraminifera contained seven species or forms, two of which were previously undescribed. The overall assemblage of

foraminifera suggest a shallow to moderately deep marine environment (McLean, 1956). This foraminiferal material is curated at the Paleontological Research Institution in Ithaca, New York. Dowsett and Wiggs (1992) studied foraminifera from the Moore House Member and Mogarts Beach Member, exposed near Moore House within COLO. Their study identified 18 different species of foraminifera present at this locality. The Moore House Member, in particular contains well-preserved and abundant forams. Common specimens include *Neogloboquadrina* and *Globigerinoides ruber*. Slightly less common were specimens of *Globigerinoides obliquus* and *G. sacculifer*. Foraminifera are important indicators of paleoenvironment. The assemblage collected from the Mogarts Beach Member within COLO indicates an approximate sea surface temperature ranging from 18.7°C (65.7°F) in winter to 25.9°C (78.6°F) in summer (Dowsett and Wiggs, 1992).

McLean (1957) followed up his 1956 work on the foraminifera of the Yorktown Formation with a description of the ostracoda of the York-James Peninsula. McLean described 30 species of ostracodes from throughout the Peninsula. The Yorktown Bluffs, Moore House Beach, and Felgates Creek (again, McLean refers to “Felgaters” Creek) localities listed in this 1957 paper are the same as those utilized in 1956. Yorktown Bluffs and Moore House Beach are within COLO boundaries, while the Felgates Creek locality is near, if not inside, present-day COLO boundaries. The Yorktown Bluffs locality did not produce any ostracodes. The Moore House Beach locality however produced 17 different species of ostracoda. Of these 17, one species, *Murrayina barclayi*, was previously unknown and was only described from the Moore House Beach locality. The Felgates Creek locality produced four species. The overall ostracode assemblage indicates relatively shallow water conditions.

Sabol (1960) reported on the ostracodes and foraminifera of the Cobhams Wharf area, located approximately three kilometers (two miles) south of Jamestown Island on the south bank of the James River. Sabol (1960) described 15 species of ostracods, McLean (1957) also collected nine of these species at the Moore House Beach locality. Sabol’s collection of foraminifera yielded 25 different species, 14 of which were also collected at the Moore House Beach locality within COLO as reported by McLean (1957).

Additional microfossils are reported from the Yorktown including fragments of bryozoans (McLean, 1956; Sabol, 1960; Johnson, 1972), brachiopods (Johnson, 1972), echinoid spines and fragments (McLean, 1956; Johnson, 1972), numerous barnacle plates (Sabol, 1960; Johnson, 1972), sponge spicules (Sabol, 1960; Johnson, 1972), and a small coral (Sabol, 1960; Johnson, 1972).

Clarke and Fitch (1975) reported the discovery of fossil cephalopod statoliths (small calcium carbonate or aragonite deposits in the ear, responsible for equilibrium) from a number of formations throughout the country, including the Yorktown in Virginia. Sabol (1960) notes the occurrence of statoliths in the Cobham Wharf area on the south bank of the James River, south of Jamestown Island. Fossil statoliths, also known as otoliths, may be present within COLO boundaries based on these discoveries in the immediate area.

Vertebrates have been reported from the Yorktown Formation. However much of the material is most likely from the Sunken Meadow Member of the Yorktown Formation, as vertebrate fossils are rarely found in the younger members of the Yorktown Formation (L. Ward, personal communication, 2003). For example, both McLean (1956) and Johnson (1972) report discoveries of fish bones within Yorktown sediments. Berry and Gregory (1906) reported on a discovery of walrus from the “beach at Yorktown, Virginia”. The jaw material found was significant in that the authors named a new genus and species, *Prorosmarus alleni*, from the material. (Berry and Gregory, 1906). Baum and Wheeler (1977) reported on vertebrae of the whale *Balaenotus* sp. found on the south bank of the James River directly across from Jamestown Island at the end of Virginia Route 636. Additional whale material was found approximately 16 kilometers (10 miles) west of Jamestown Island near Sunken Meadow Pond on the south bank of the James River (Baum and Wheeler, 1977). Johnson (1972) reported what may be an *Orycterocetus* (sperm whale) tooth found within the R.L. Brandt & Sons gravel pit about 6.5 kilometers (four miles) southeast of Moore House near Fish Neck. While not within COLO boundaries, these discoveries indicate the possibility for similar material to be located within the park. Additionally, Ward (personal communication, 2003) indicated that whale material was discovered during the early summer of 2003 during an archeological survey at a fort near Indian Field Creek.

While extraordinarily abundant, and extraordinarily varied, paleontological resources have been described from the Yorktown Formation within COLO, there is little future potential for additional finds at the classic localities. The best exposures of the Yorktown Formation were along the south bank of the York River. This bank, however, was ripped in the 1950s to slow erosion. This riprap completely covers many of the fossiliferous exposures making them

inaccessible (L. Ward, personal communication, 2003; Ward, 1993). McLean (1956) also commented on the loss of paleontological collecting and research sites due to bank conservation practices throughout the York-James Peninsula.

While riprap obscures some of the classic collecting localities, there is still potential for unauthorized collection of paleontological resources. In fact, Burns (1991) published a popular guide to collecting fossils in the Mid-Atlantic region. The book describes a collecting locality located within COLO, along the south bank of the York River at the mouth of Indian Field Creek. Unauthorized fossil collectors may be visiting this location and may be removing fossils from the park. However, collections made below high mean tide are technically out of COLO boundaries (C. Rafkind, personal communication, 2003).

The Yorktown area and Yorktown Formation of COLO has been the subject of the majority of geological and paleontological research within the park. However, Johnson and Hobbs (2001) do report on the geology of the Jamestown area. The marsh, estuary, and beach sediments found on the surface of Jamestown Island are relatively young, dating from the late Pleistocene and Holocene. These sediments have been assigned to the late Pleistocene Tabb Formation and the Kennon formation (an informal name). These young surficial units cover nearly 305 meters (1,000 feet) of Miocene and older sediments not exposed on the surface. Fossils found in the Jamestown Island area are mainly pollen and phytoliths (small mineral deposits formed within plants). Spores and foraminifera are also found and contribute to paleoecological reconstruction of the Jamestown area. These various types of microfossils, taken together, date back approximately 37,000 years and contain a nearly continuous record to present day (Johnson and Hobbs, 2001). Palynological (pollen) studies were conducted near Great Dismal Swamp 70 kilometers (44 miles) south-southeast from Jamestown Island. However, Johnson and Hobbs (2001) reported that because of limited elevation change between the two sites, paleoclimatological data is applicable to the Jamestown area. Grafton Pond (18 kilometers (13 miles) east of Jamestown), Kingsmill Creek (within COLO), and the Back River Marsh (within COLO) were other palynological survey sites, where geological core samples were obtained. Phytoliths (mineral deposits that form within plants) from four families of grasses in addition to oak and pine trees were studied from cores obtained in Back Water Marsh area and date from 5,000 years before present. Protists including foraminiferids and thecaemobinids were described from the Middle James Estuary and range in age from 6,000 years to modern day. Overall, the microfossil record is not complete, but indicates that during the late Pleistocene, the Jamestown areas was covered with a boreal (northern) forest with spruce, fir, and cool climate pines (Johnson and Hobbs, 2001). Between 11,000 and 8,000 years before present, these northern species declined. Oak, hickory, temperate climate pines, and sweet gum, among others then flourished (Johnson and Hobbs, 2001).

COOPERATIVE PROJECTS

- Johnson and Hobbs' investigation of the geology of the Jamestown Island was performed within COLO, supported by College of William and Mary and Colonial Williamsburg Foundation (Johnson and Hobbs, 2001).

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- DS-COLO-XXX Inventory of Paleontological Resources Associated with National Park Service Caves. 1997-2001. (field notes; photographs; publication). Originated by Santucci, Kenworthy, and Kerbo; status: Inactive.
- DS-COLO-XXX Smithsonian Institution National Museum of Natural History Collections. 1890s-present. (museum specimens; associated specimen notes; collections records; field notes). Originated by NMNH Staff; status: Active.